# Accuracy Assessment Protocol

### Purpose

To quantitatively assess the accuracy of a land cover map

To identify the types of errors that occur on a land cover map

### Overview

Students will perform an accuracy assessment on the land cover map they have generated either by manually interpreting or unsupervised clustering of the Landsat Thematic Mapper image of their GLOBE Study Site. Validation data collected at various Land Cover Sample Sites, which were not used in the development of the map, will be used to compare with the land cover map, and a difference/error matrix will be generated.

### Time

Approximately 2 hours depending on the number of validation samples collected

### Level

All

### Frequency

Once for each land cover map. The accuracy assessment can be repeated when more validation sites have been measured; the statistical validity of the accuracy assessment improves as more samples are used.

An accuracy assessment can be performed on only a portion of the map.

### Key Concepts

Accuracy assessment allows evaluation of our ability to map land cover.

The difference/error matrix

### Skills

*Building* and *analyzing* a difference/error matrix for accuracy assessment

*Solving* problems cooperatively to resolve accuracy issues

### Materials and Tools

Natural color, hard-copy TM image of your 15 km x 15 km GLOBE Study Site

False color infra-red, hard-copy TM image of your 15 km x 15 km GLOBE Study Site

MUC classification work sheet

Difference/error matrix work sheet

### Preparation

Have copies of the necessary Work Sheets so the students can quickly compare the Land Cover Sample Sites to the appropriate location on the land cover map and generate the difference/error matrix.

### Prerequisites

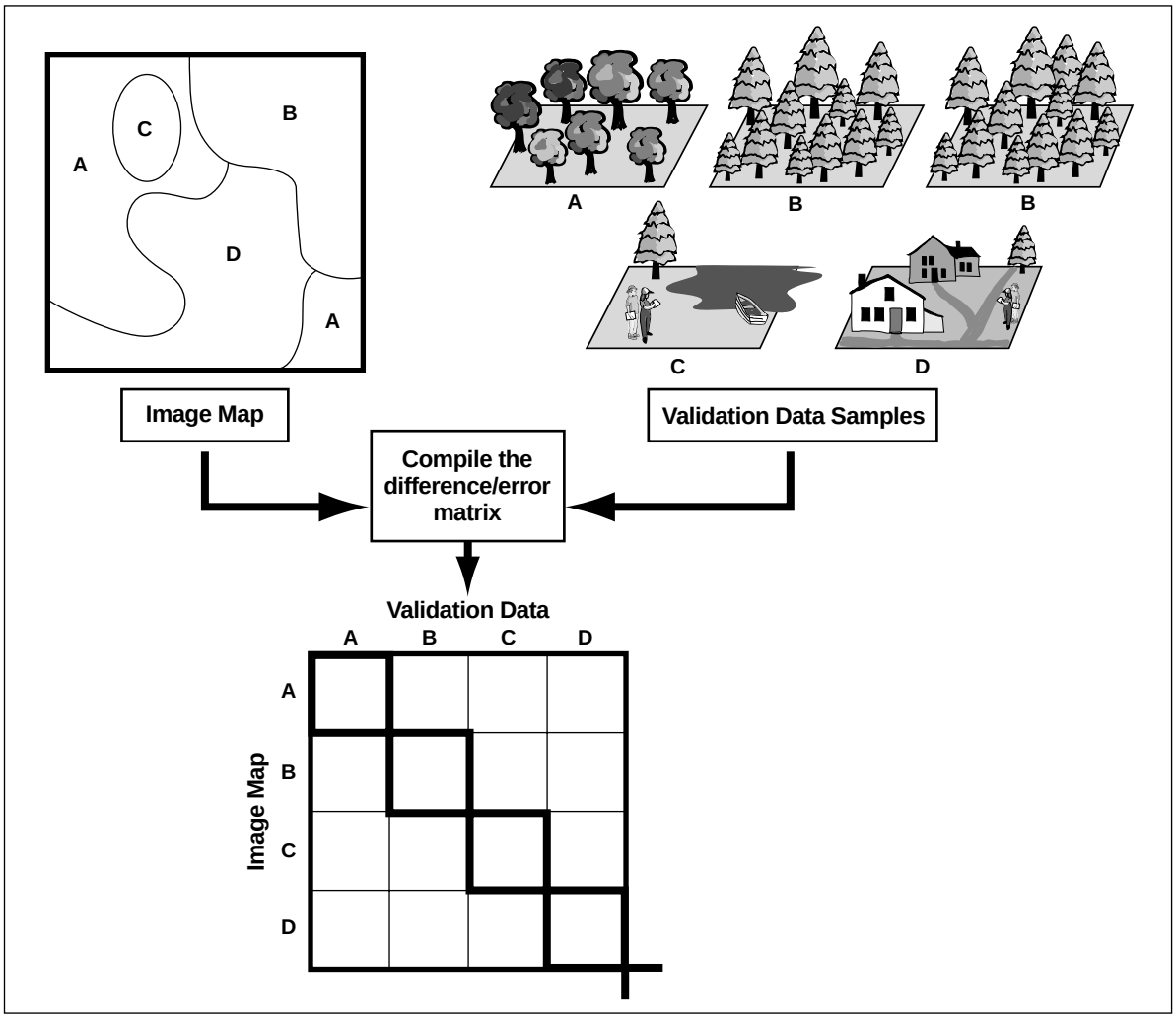
Either of the *Land Cover Mapping Protocols*

*Introducing the Difference/Error Matrix Learning Activity*

### Introduction

In this protocol students will assess the accuracy of the land cover map generated from the remotely sensed data. See Figure LAND-P-18. It does not matter whether the land cover map was created through manual interpretation of an image or generated using the MultiSpec software and unsupervised clustering. In both cases, it is still important to compare the land cover map to Land Cover Sample Sites measured on the ground. A difference/error matrix will be generated to serve as a framework for analyzing the errors which occur in the land cover map. In the case of a land cover map generated from a satellite image using

*Figure LAND-P-18: Accuracy Assessment Process*




unsupervised clustering, some of the errors may be related to the fundamental limitations of the satellite image data as a tool in distinguishing land cover classes.

The following information is needed to generate a difference/error matrix:

- Land cover map generated from remotely sensed data
- Validation Land Cover Sample Sites

In order to generate a difference/error matrix, it is necessary to have validation data (Land Cover Sample Sites) collected for each land cover type in the Globe Study Site that you wish to assess. Ideally, it would be great to have samples for every land cover type. It may not be possible to collect all these samples and therefore, it may be desirable to only generate the matrix for the 3 or 5 most common types. The more samples collected for each land cover type, the more statistically valid the matrix will be. Over time, every school should be able to collect enough data to generate at least a limited difference/error matrix.

Once the validation data has been collected according to the protocols outlined in the *Qualitative* and *Quantitative Land Cover Sample Site Protocols*, it is possible to begin creating a difference/error matrix. This difference/error matrix should have a row and column for each and every MUC class that is on the MUC Classification Data Work Sheet (i.e. every MUC class that occurs for a land cover sample site or that labels any area on that portion of the land cover map that is being validated). See Table LAND-P-5. In this example there are four MUC classes: code 0222, code 0221, code 1121, and

code 811. In the corresponding difference/error matrix (Table LAND-P-6), there is a column and a row for each of these four classes. For sample number 1 on the Example MUC Classification Data Work Sheet (Table LAND-P-5), you look up the Student MUC Classification for this area of the land cover map (Table LAND-P-5 cell A-Mainly cold-deciduous forest with some evergreen needle leafed trees, MUC code 0222 at level 4). In Table LAND-P-6, the Difference/Error Matrix you find the matching in the left-hand column (the first row for MUC Code 0222). For sample number 1 on the Example MUC Classification Work Sheet (Table LAND-P-5), you determine that the validation data from the Land Cover Sample Sites (Table LAND-P-5-cell B) is mainly cold-deciduous forest with evergreen broad leafed trees, MUC code 0221. In Table LAND-P-6 the Difference/Error Matrix, from the cell with the identified Student Classification MUC code 0222, you move along the row (left-to-right) until you find the column with a label which matches the Validation Data MUC code 0221. In the cell at the intersection between the MUC code 0222 row and the MUC code 0221 column, (cell B1), you mark one tally and move to the next sample. In this way, the rows represent the areas of the map and the columns represent the validation data. The overall accuracy is calculated using the procedure illustrated in Table LAND-P-6.

It should be understood that collecting validation data (Land Cover Sample Sites) is a time consuming process; it may take numerous classes to put together enough data for a valid matrix. This is an excellent place within GLOBE to rely on a learning community to cooperate in accomplishing a protocol. Using Qualitative Land Cover Sample Sites will greatly speed up this process; however, scientifically, Quantitative Land Cover Sample Sites are preferred.

## How to Tally Validation Data on a Difference/Error Matrix and Calculate Overall Accuracy

Refer to Tables LAND-P-5 and LAND-P-6 to help you understand the following procedures.

### Step 1: Preparation

- ❑ It is important to remember not to look at what you, the student, labeled an area before going out to collect validation data for that same area. Knowing what the image

*Table LAND-P-5: Example MUC Classification Data Work Sheet*

| Sample Number | Site Name | Student Classification on a Land Cover Map | Validation Data from Land Cover Sample Sites | √ | X |
|---|---|---|---|---|---|
| 1 | Brown's Woods | A: Mainly cold-deciduous forest with some evergreen needle leafed trees (MUC code 0222) | B: Mainly cold-deciduous forest with evergreen broad leafed trees (MUC code 0221) | | X |
| 2 | Smith State Park | C: Mainly evergreen wood-land with rounded crowns and needled leaves (MUC code 1121) | D: Mainly evergreen wood-land with rounded crowns and needled leaves (MUC code 1121) | √ | |
| 3 | Appleby Farm | E: Pasture (MUC code 811) | F: Pasture (MUC code 811) | √ | |
| 4 | Green's Woods | G: Mainly cold-deciduous forest with evergreen broad leafed trees (MUC code 0221) | H: Mainly cold-deciduous forest with evergreen broad leafed trees (MUC code 0221) | √ | |

*Table LAND-P-6: Difference /Error Matrix Example*

**Validation Data**

| Map Classification | MUC code 0222 | MUC code 0221 | MUC code 1121 | MUC code 811 | **Row Total** |
|---|---|---|---|---|---|
| MUC code 0222 | **A1:** | B1: 1 | C1: | D1: | E1: 1 |
| MUC code 0221 | **A2:** | B2: 1 | C2: | D2: | E2: 1 |
| MUC code 1121 | **A3:** | B3: | C3: 1 | D3: | E3: 1 |
| MUC code 811 | **A4:** | B4: | C4: | D4: 1 | E4: 1 |
| **Column Total** | **A5: 0** | B5: 2 | C5: 1 | D5: 1 | E5: 4 |

$$\mathbf{E5} = \mathbf{A5} + \mathbf{B5} + \mathbf{C5} + \mathbf{D5} = \mathbf{E1} + \mathbf{E2} + \mathbf{E3} + \mathbf{E4}$$

(column total) = (row total)

$$\text{Overall Accuracy} = \frac{\mathbf{A1} + \mathbf{B2} + \mathbf{C3} + \mathbf{D4}}{\text{E5}} * 100 = (3/4) * 100 = 75\%$$

classification says an area is before collecting the validation data biases the collection. Therefore, validation data should be collected on the Data Work Sheet outlined in the Land Cover Sample Site Protocols and then the example Table LAND-P-5 should be created in the classroom after the data has been collected and recorded. Table LAND-P-5 can then be used as the input to create the difference/error matrix. A check is used to represent agreement between the student classification and the validation data while an X denotes a difference.

### *Step 2: Build an empty difference/error matrix*

- ❑ Build an empty square matrix. There should be a column and row in the matrix for every MUC class that occurs in the validation data or on the portion of the land cover map that is being validated. Label each of the columns and rows of the matrix with one of these MUC classes. Be sure that the labels are in the same order starting from the upper left-hand corner going down and across. Be sure to include a right-hand column and a bottom row for totals

### *Step 3: Identify student classification from map for sample 1*

- ❑ For a sample on your MUC Classification Work Sheet, look up the Student MUC Classification for the area of the land cover map in which this sample site is found.

### *Step 4: Find appropriate row in matrix for data*

❑ Find the row in your matrix corresponding to the area of the map in which this land cover sample site is located.

### *Step 5: Identify MUC class from validation data for sample*

❑ On your MUC Classification Work Sheet, look up the validation data MUC Classification for this sample site.

### *Step 6: Find appropriate cell in matrix for data and tally*

❑ Move along this row from left to right to the box in the column labeled with the MUC class corresponding to that of the validation data. Mark one tally in this box.

### *Step 7: Repeat steps 3 through 6 for each sample*

❑ Repeat this process for each sample on your MUC Classification Work Sheet. After you have completed tallying all of the samples, calculate the totals for each row and column. If the sum of the row totals does not equal the sum of the column totals, recheck your arithmetic.

### *Step 8: Calculate overall accuracy*

❑ Sum the number of tallies in all the boxes on the major diagonal of the matrix (i.e. the boxes for which the row and column labels are the same) except the lower right-hand total box. Divide this sum by the total number of samples which is equal to the value in the lower right-hand box. Multiply this quotient by 100 to convert it to a percentage. Refer to the example in Table LAND-P-6.

### *Step 9: Interpret results*

❑ Just as the cells along the major diagonal represent all the correct classifications or agreement between the student classification of the map and the validation data collected by students at Land Cover Sample Sites, the cells which are off the major diagonal represent incorrect classifications or the differences. Hence the name difference matrix or error matrix. This information can be used to identify MUC classes that were particularly difficult to classify, and also which MUC classes were confused with each other.

Figure LAND-P-17 presents a difference/error matrix for three broadly generalized land cover categories. This matrix is simply a cross-classification comparing the map categories to the validation data. In the places that agreement occurs, a tally is made along the major diagonal. Differences or errors are represented by the off-diagonal elements of the matrix. In addition to depicting the matrix as a 2 dimensional table, it can also be represented 3 dimensionally. In this case, it is easy to see that the more accurate the map, the bigger the blocks along the major diagonal.

## *Reporting the Data*

Report all difference/error matrices to the GLOBE Student Data Base.

*Figure LAND-P-17: A Difference/Error Matrix for Broad Land Cover Categories*

**Validation Data**

| Classified Data (Map) | F | W | U | Row Total |
|---|---|---|---|---|
| F | 28 | 14 | 15 | 57 |
| W | 1 | 15 | 5 | 21 |
| U | 1 | 1 | 20 | 22 |
| Column Total | 30 | 30 | 40 | 100 |

**Land Cover Categories**

F = Forest

W = Water

U = Urban

**Overall Accuracy = 63/100 = 63%**

**Producer's Accuracy**

F = 28/30 = 93%

W = 15/30 = 50%

U = 20/40 = 50%

**User's Accuracy**

F = 28/57 = 49%

W = 15/21 = 71%

U = 20/22 = 91%

*Figure LAND-P-18: A 3-D View of a Difference/Error Matrix*